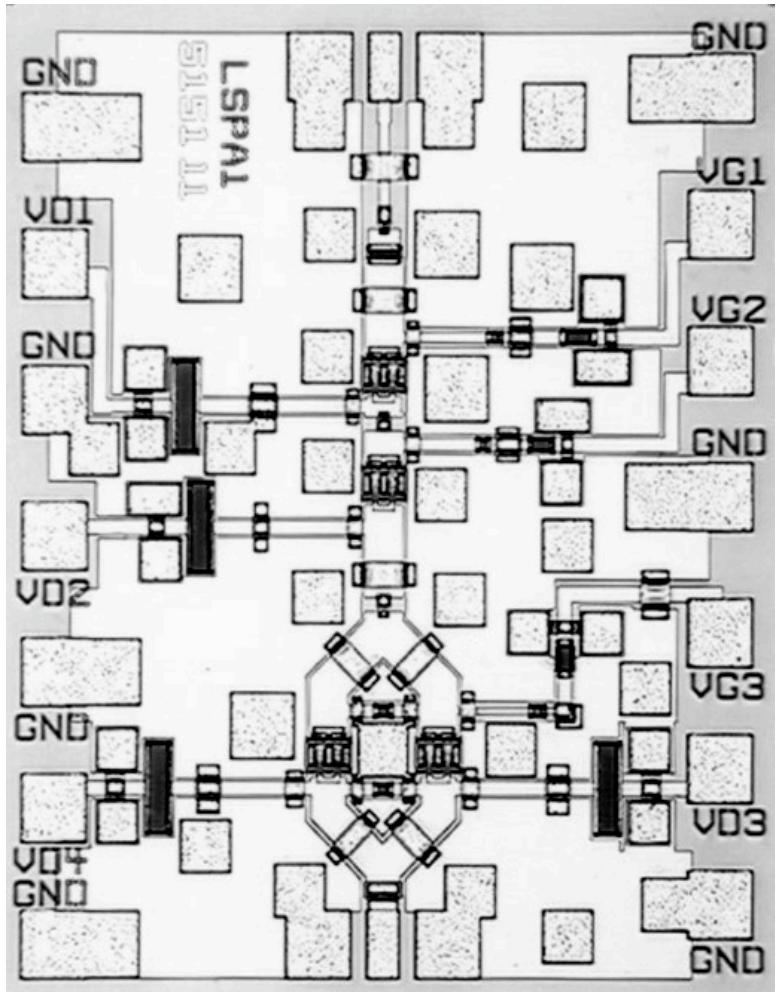


Abstract – This paper focuses on InP-based, HEMT Monolithic Millimeter-wave Integrated Circuit (MMIC) power amplifiers for applications to heterodyne receivers, transmitters, and communications circuits. Recently, we have developed several HEMT MMIC circuits using HRL Laboratories' 0.1 um InP HEMT technology with unprecedented high frequency performance and output power. Our results include an 80 GHz bandwidth power amplifier to 145 GHz, a 15-25 mW amplifier to 170 GHz and a HEMT active doubler to 300 GHz, the highest frequency HEMT doubler circuit reported to date. We will report on the design and testing of the circuits, and discuss the methods involved in measuring MMICs above 200 GHz. These circuits are particularly useful in local oscillators for heterodyne receivers at THz frequencies.

HEMT Devices

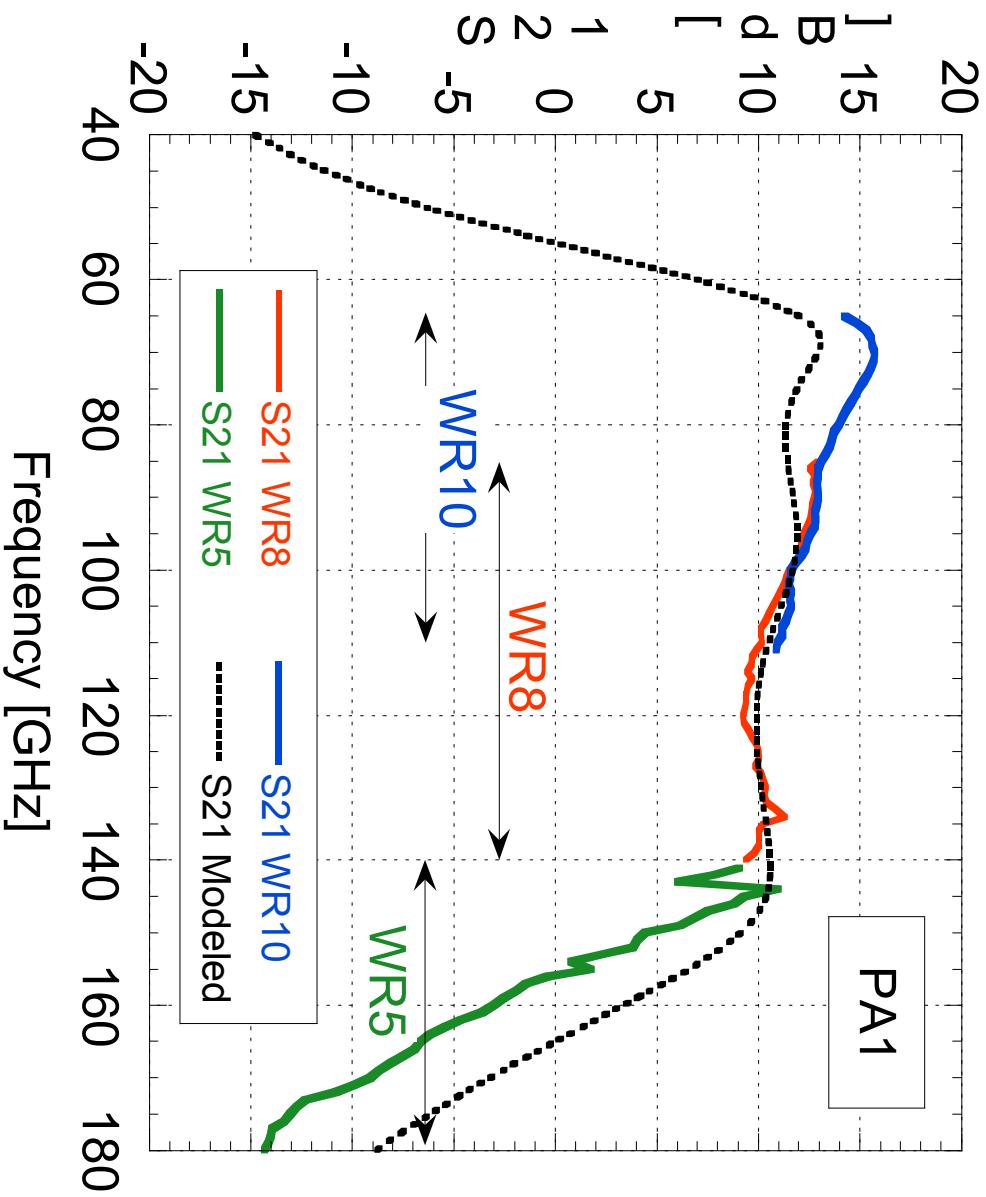
- Fabrication at HRL Laboratories, LLC
- InP HEMT process
- 0.1 μ m gate length, 4 finger \times 37 microns
- Total periphery = 148 μ m
- 50 μ m thick InP substrate

65-145 GHz Medium Power Amplifier Chip

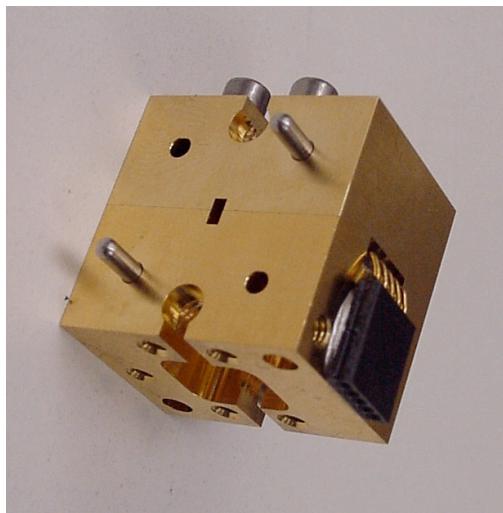


- Grounded CPW Geometry
- 70 μ m gnd-to-gnd spacing
- Area: 1.2 mm x 1.4 mm
- 3-stage design
- Stg 3: 2 HEMTs in parallel
- Angelov Model for HEMTs
- Via holes to suppress substrate modes

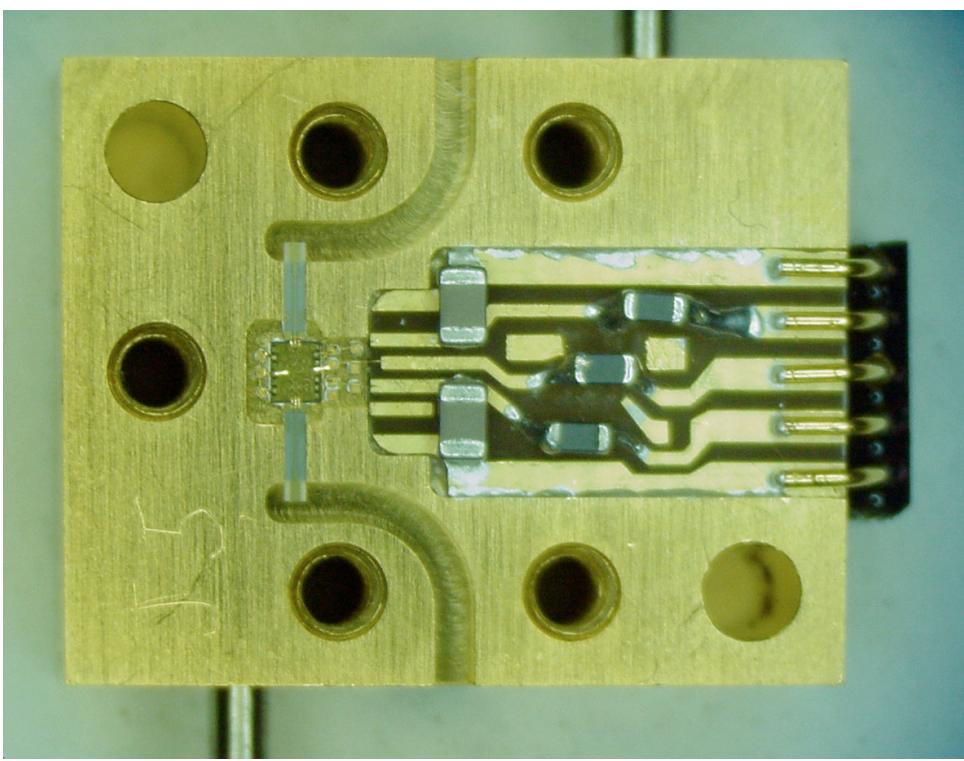
S-Parameter Measurements: S₂₁



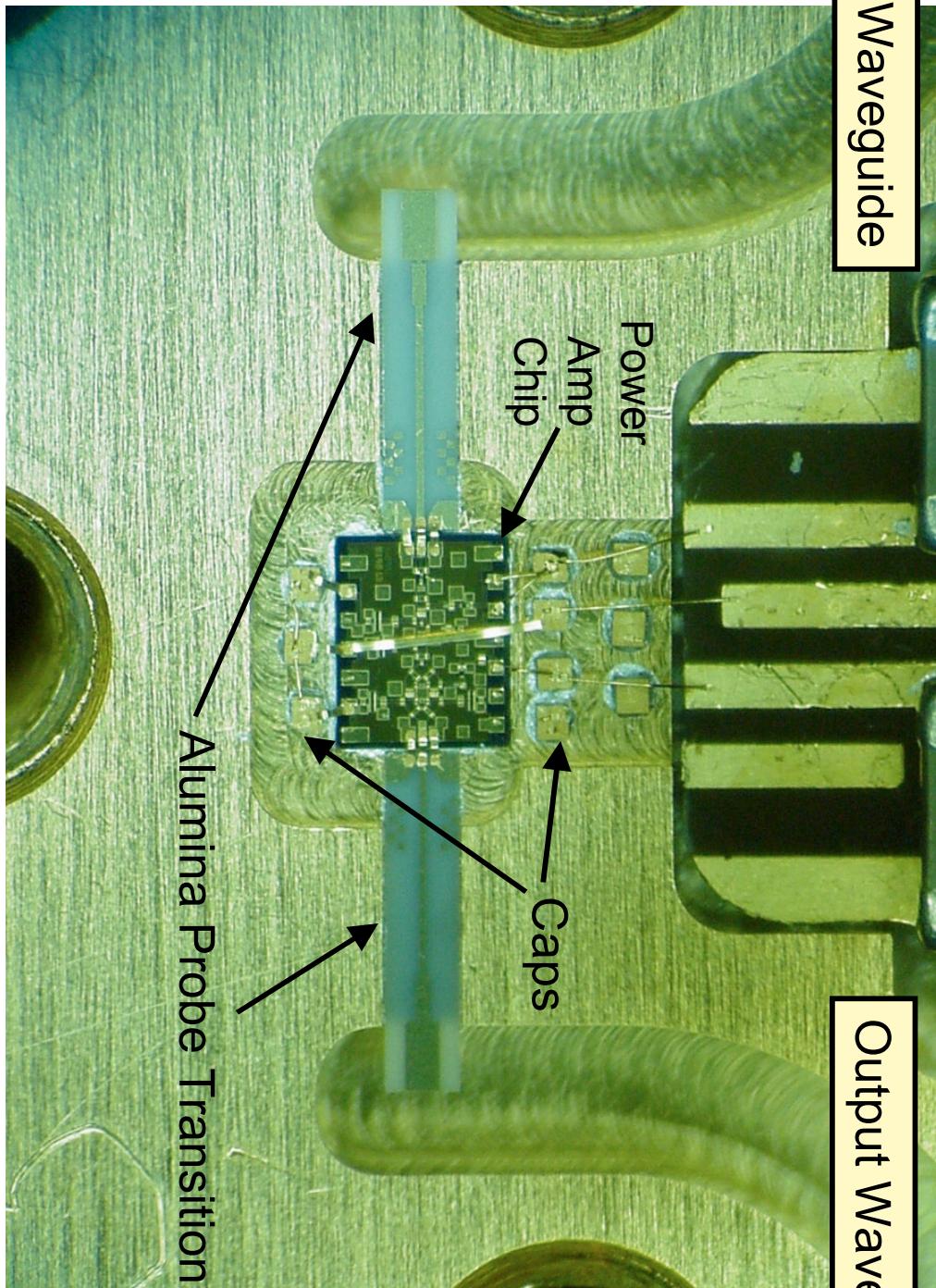
Power Amplifier Module 90-140 GHz



- WR8 Waveguide compatible
- $P_{out} \sim 20 \text{ mW}$ at 83, 94, 100 GHz
- Chip nominal 6 dB large signal gain
- Module ~4-5 dB large signal gain
- Modules can be cascaded for gain
- Easily power-combined in waveguide



Closeup of WR8 Module with PA chip



Advanced HEMT MMIC Circuits for Millimeter and Submillimeter Power Sources

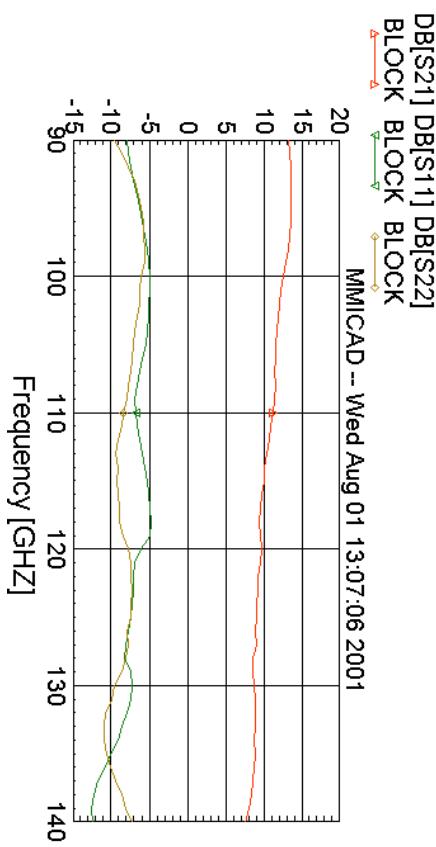
L. Samoska, J. Bruston, and A. Peralta

Measured Gain and Power of WR8 Amp Block

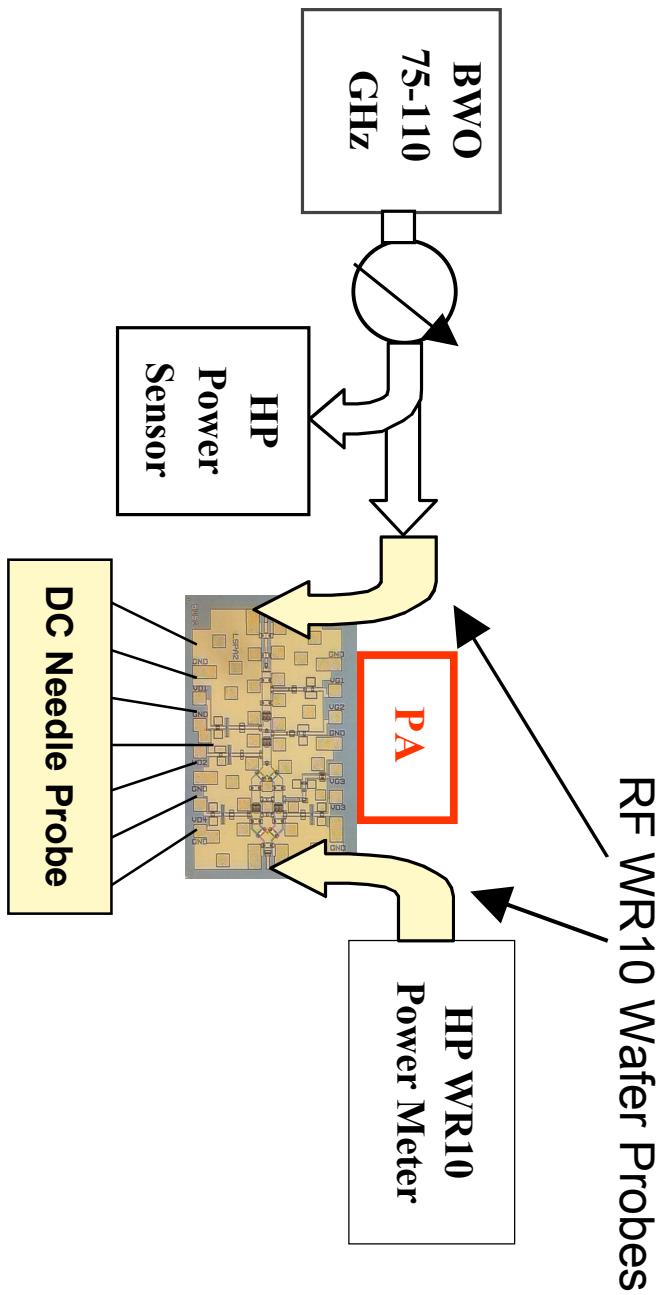
J6 WR8 Block for LSPA1 chip



HRL AMP LSPA1



On-Wafer Test Set for W-Band Power Amp Measurements



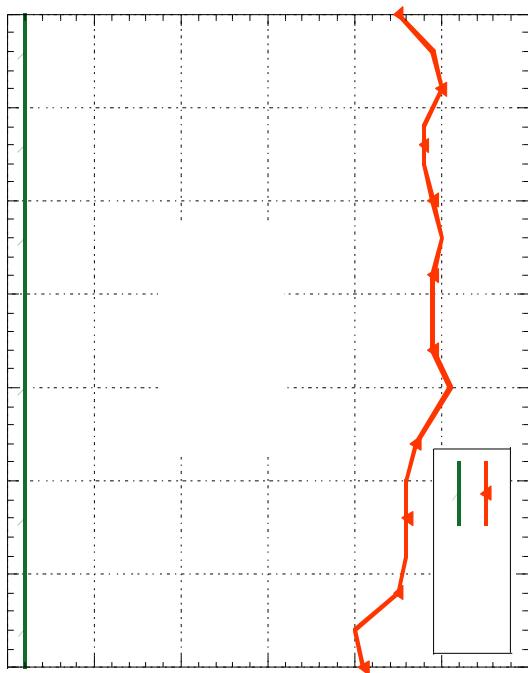
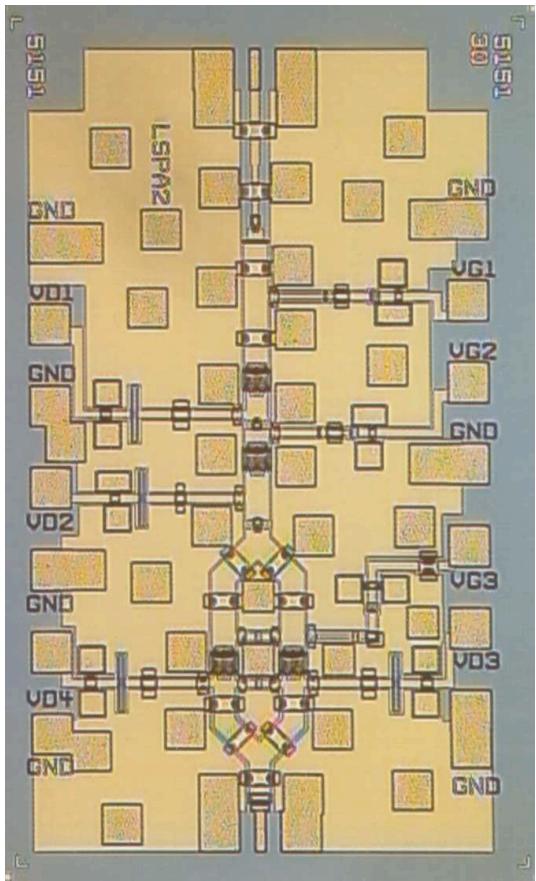
Advanced HEMT MMIC Circuits for Millimeter and Submillimeter Power Sources

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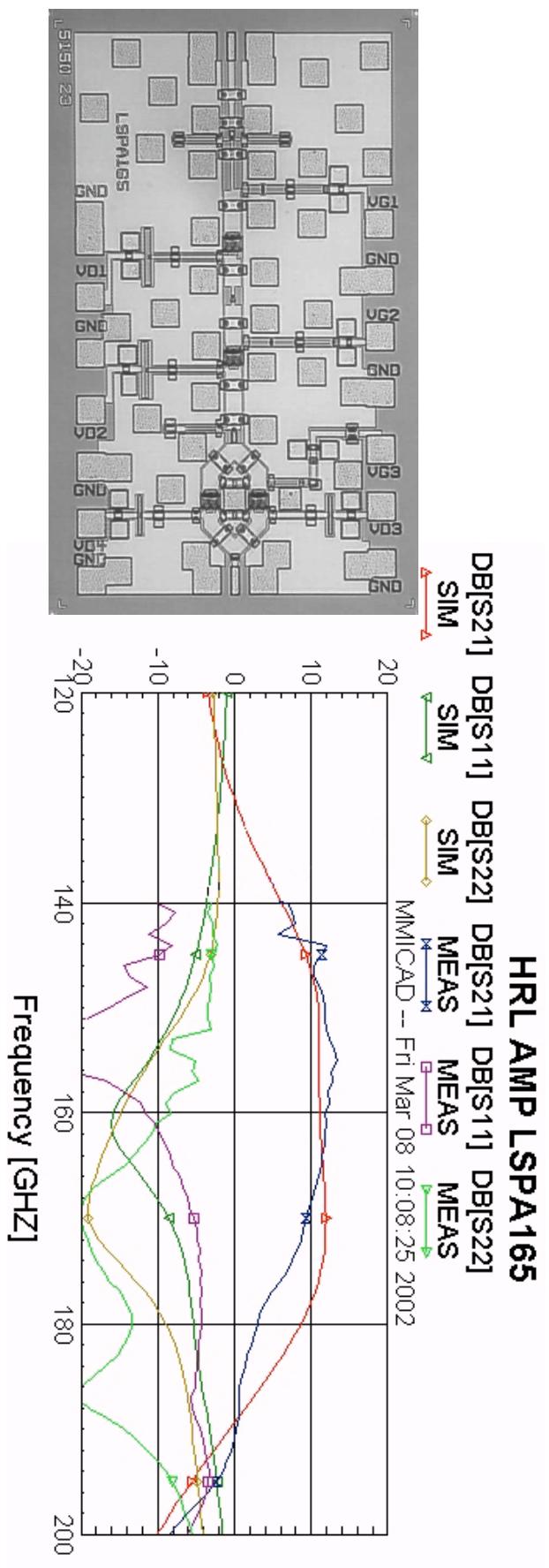
WR10 Full Waveguide Amplifier 75-110 GHz, >40 mW

01020304050607580859095100105110P_{out}[mW]P_{in}[mW]

f_{rec}



140-170 GHz Medium Power Amplifier

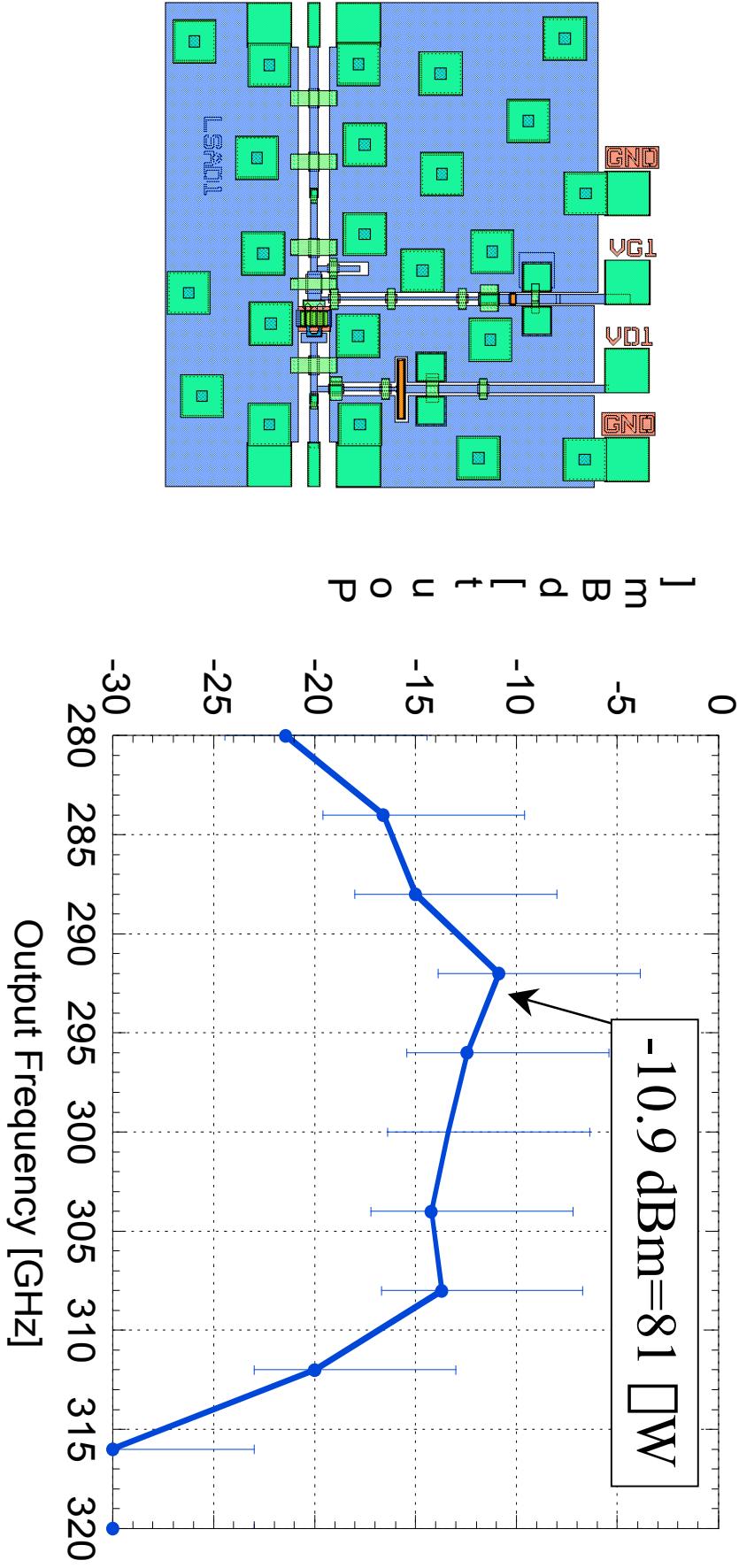


- Fastest solid-state power amplifier chip developed to date
 - 10 dB gain, 15-25 mW available power

Advanced HEMT MMIC Circuits for Millimeter and Submillimeter Power Sources

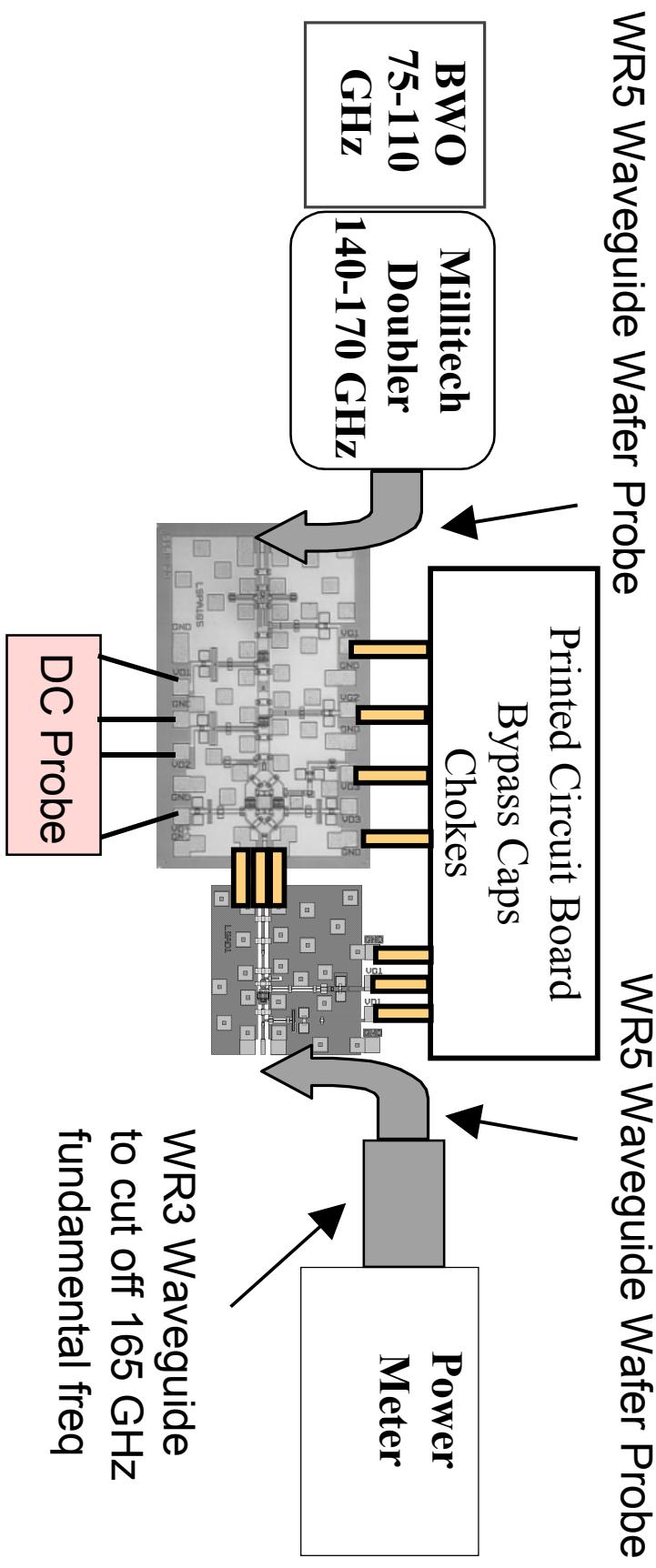
L. Samoska, J. Bruston, and A. Peralta

First 300 GHz HEMT Doubler Results



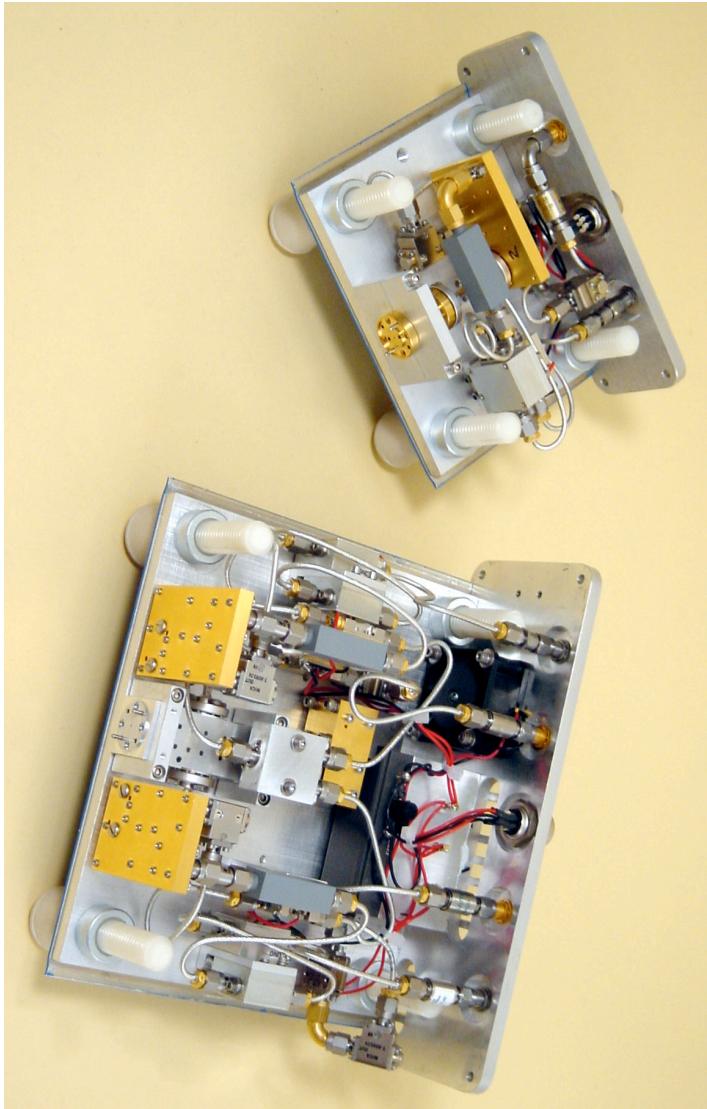
$P_{in} \sim 10 \text{ mW}$ between 140-160 GHz

Testing of HEMT Doubler Circuit at 300 GHz



- Use Power Amp wire-bonded to Doubler

WR3 Frequency Extenders for 220-325 GHz (Oleson Microwave Labs)



- Enables Full 2-port S-parameter Vector Network Analyzer measurements
- Future Amplifier MMICs can be tested to 325 GHz!